# POLARITY of GaN GROWN on (001) b-$LiGaO_2$

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A (001) β-$LiGaO_2$ (LGO) substrate is a promising material for the epitaxial growth of GaN because its lattice-mismatching is nearly an order of magnitude smaller than that of (0001) sapphire. Though commercially available LGO includes many anti-phase domains, we have grown bulk LGO with a single domain by using Czochralski technique and pulling in a direction perpendicular to the c-axis[(1)]. In this paper, we describe the characteristics of GaN grown by MOVPE on a metal-surface and an oxygen-surface of (001) LGO.

The MOVPE system we used had a vertical reactor with a cold wall. The source gases were ammonia, TMG, and TEG, and the reactor pressure was 650 Torr. (0001) GaN was grown on both a metal-surface consisting of lithium and gallium, and on an oxygen-surface. Two kinds of surfaces were distinguished from the difference in the etching characteristic in an aqueous solution of nitric acid ($H_2O$ : $HNO_3$=1:1) as an etchant. The hardly etched surface and the easily etched one consisted of metal and oxygen atoms, respectively[(2)]. The substrate was protected from the reducing atmosphere such as ammonia and hydrogen during GaN growth, by covering its back surface with $SiO_2$. After a 20 nm-thick buffer layer of GaN was grown at 550°C, this layer was crystallized and a thick layer of GaN was grown at temperature between 800°C and 900°C. ere, the buffer layer also plays the role of the protector of the front surface. The polarity of GaN was determined by coaxial impact collision ion scattering spectroscopy (CAICISS), which is a method using ion channeling. In the experiment, $He^+$ ions with an energy of 2 kV were used and the recoiled $He^+$ ions by gallium and nitrogen atoms were selectively counted, using the difference in the time of flight between gallium and nitrogen atoms.

GaN grown on a metal-surface LGO showed a mirror-like surface and the band-edge emission without the yellow band luminescence in photoluminescence (PL) at room temperature. GaN grown on an oxygen-surface, on the other hand, sometime showed cracks generated and peeling from the substrate. In PL from this GaN, the yellow band emission as strong as the edge emission was observed.

The results of the polarity measurement are shown in Figs. 1 and 2. Figure 1 shows the azimuth-angular dependence of the Ga and N signals measure in GaN on the metal surface LGO. The incident angle of $He^+$ ions to the GaN surface was an elevation angle of 58.4° from (0001) plane, in which angle the ion channeling most easily occurs. The nitrogen signal is much weaker than the gallium signal because the mass of nitrogen atom is much smaller than that of gallium atom. The experimental data coincide with the simulation results obtained using the model shown in the inset, confirming the three-fold symmetry expected form the considerations of the crystallography. This means that the quality of this GaN is high. Using the azimuth angle determined from the

first sharp dip of the simulation in Fig. 1, we evaluated the polar-angular dependence of Ga-signal intensity along the [11-20] azimuth. As shown in Fig. 2, these experimental and simulation results also show good agreement. This result means that GaN on a metal-surface LGO has a +C polarity. The polarity of GaN grown on oxygen-surface LGO is mixed, so its characteristics are not as good as those of GaN grown on metal-surface LGO.

In summary, by CAICISS we found that GaN grown on metal-surface (001) LGO has +C polarity and forms high-quality crystals.

(1) T. Ishii et al., Mat. Res. Soc. Proc., 468(1997)155.

(2) T. Ishii et al., Jpn. J. Appl. Phys., 37(1998)L672.

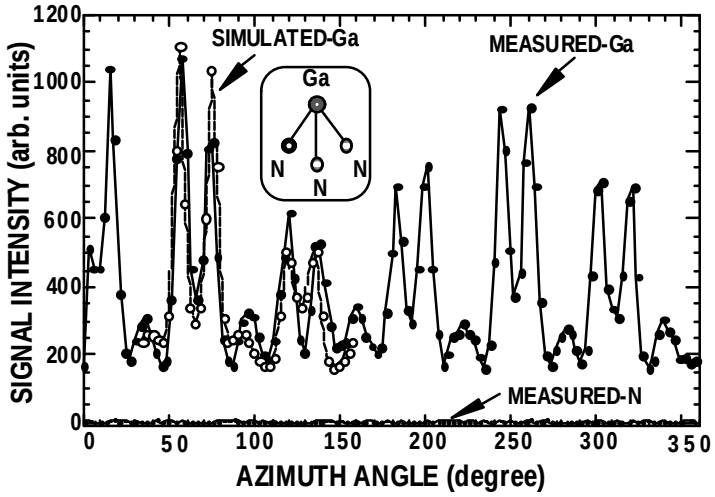


Fig.1 Azimuth-angular dependence of Ga and N signal intensity for GaN on Li, Ga-surface LGO. Dotted line shows the simulation of Ga signal intensity by using the model shown in the inset.

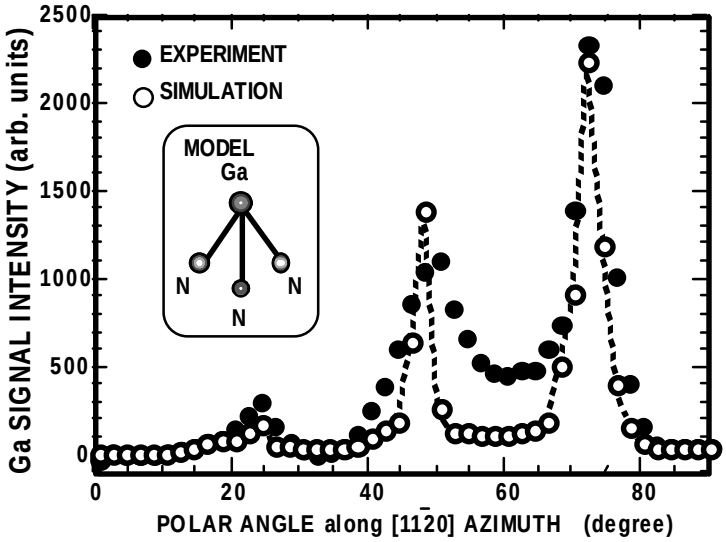


Fig.2 Polar-angular dependence of Ga-signal intensity along the [11-20] azimuth from GaN on Li, Ga-surface LGO. Dotted line shows the simulation of Ga signal intensity by using the model shown in the inset.